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From (5) and (6), $z=t-s$. Therefore, from (4), $x^5+y^5=r-(t-s)^5$.

Dividing this by (5) and subtracting (5) raised to fourth power from the result

$$x^2+xy+y^2=\frac{r-(t-s)^5-s^5}{-5sxy}.$$

But from (5), $x^2+xy+y^2=s^2-xy$.

$$\therefore\ x^2y^2-s^2xy=\frac{r-(t-s)^5-s^5}{5s},\text{ and } xy=\tfrac{1}{2}s^2\pm\sqrt{\frac{r-(t-s)^5-s^5}{5s}+\frac{s^4}{4}}\ ..(8).$$

Subtracting (8) multiplied by 4 from (5) squared, and taking square root obtain $x-y$, from which with (5),

$$x=\tfrac{1}{2}s\pm\tfrac{1}{2}\sqrt{-s^2\mp4\sqrt{\frac{r-(t-s)^5}{5s}+\frac{s^4}{4}}}$$

whence x by substitution from (7), then x and y from (5) and (6).

Also solved by *J. SCHEFFER*, and *G. B. M. ZERR*.

122. Proposed by JOSIAH H. DRUMMOND, LL. D., Portland, Me.

A man buys a five per cent. ten-year bond at such a price as enables him to spend annually three per cent. upon his investment and by continually investing the residue of the annual interest and its increase annually at four per cent., at the end of term upon payment of his bond has his original investment. What price per $100 does he pay for the bond?

Solution by D. G. DORRANCE, JR., Camden, Oneida County, N. Y.; and H. C. WHITAKER, A. M., Ph. D., Manual Training School, Philadelphia, Pa.

At the beginning of the time, the man pays $$x$ for the bond; at the end of the time, he receives $100 and an accumulated annuity of (5-.03x$) running for 10 years at 4%. The value of the annuity at that time was $25(1.04^{10}-1)(5-03x),=12.0061(5-.03x)$.

Hence $x=100+12.0061(5-.03x)$, from which $x=\$117.6537$.

By a slightly different construction which allows for only *nine* years' expenditure, Professor Zerr obtains the result $116.548.

MECHANICS.

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118. Proposed by M. E. ANDERSON, Minneapolis, Minn.

A closed steel cylinder of length L and diameter D is placed in a horizontal position. The cylinder is filled with water to a depth (a) from the lower side, the space above the water being filled with air at a pressure P_1.

What work will be done against this increasing pressure, and against gravity, by a pump forcing water into this tank until the pressure has increased to P_2? Suppose the level of the water in the tank at the beginning to be the same as that of the reservoir from which the water is pumped.

Solution by G. B. M. ZERR, A. M., Ph. D., Professor of Chemistry and Physics, The Temple College, Philadelphia, Pa.

Let v_1=volume of gas at pressure P_1.
v_2=volume of gas at pressure P_2.
v=volume of gas at pressure P.

Work done by isothermic expansion from v_2 to v_1 is

$$w=\int_{v_2}^{v_1} Pdv.$$

But $P=P_2v_2/v$.

$$\therefore\ w=P_2v_2\int_{v_2}^{v_1}\frac{dv}{v}=P_2v_2\log(v_1/v_2).$$

The work done against gravity by lifting C cubic feet of water through an average height $\frac{1}{2}l$ is $W=\frac{1}{2}Cl\times 62\frac{1}{2}=\frac{125}{4}Cl$.

Volume of water$=\frac{1}{4}\pi aD^2$, $v_1=\frac{1}{4}\pi D^2(L-a)$.

$$v_2=\frac{P_1v_1}{P_2}=\frac{\pi D^2P_1}{4P_2}(L-a).$$

$$C=v_1-v_2=\tfrac{1}{4}\pi D^2(L-a)\left(\frac{P_2-P_1}{P_2}\right).$$

$$l=\frac{(L-a)(P_2-P_1)}{P_2},\quad \frac{v_1}{v_2}=\frac{P_2}{P_1}.$$

$$\therefore\ w=\tfrac{1}{4}\pi D^2P_1(L-a)\log\left(\frac{P_2}{P_1}\right).$$

$$W=\tfrac{125}{16}\pi D^2(L-a)^2\left(\frac{P_2-P_1}{P_2}\right)^2.$$

Total work done$=w+W$.

Work done against pressure is the same as the work of expansion.

P_1 and P_2 are supposed to be given in pounds.

120. Proposed by W. J. GREENSTREET, M. A., Editor of The Mathematical Gazette, Stroud, Gloucestershire, England.

I project an elastic particle along a chord c of a smooth fixed circular rim of diameter d. The coefficient of elasticity between the particle and the rim is e, and the particle continually rebounds. Find the length of the chord described after the nth rebound.

Solution by G. B. M. ZERR, A. M., Ph. D., Professor of Chemistry and Physics, The Temple College, Philadelphia, Pa.

Let β, β_1, β_2, β_3, ...β_n be the angles the particle makes with the diameter before the first and after the first, second, third, and nth rebound, respectively, x=length of chord ofter the nth rebound.